Gordon McKay Laboratory
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Cambridge, Massachusetts

Semi-Annual Status Report on NASA Grant NsG-579

for the period

1 January 1965 through 30 June 1965

Prepared for
Grants and Research Contracts Division
Office of Space Science and Applications
National Aeronautics and Space Administration
Washington, D.C. 20546

An antenna which is a combination of the resonant V-antenna and the traveling-wave dipole antenna was studied both theoretically and experimentally. The universal curves which are useful for determining the values of the length of the antenna arms, apex angle, and loading resistors have been found. The theoretical curves for the radiation pattern agree in a general sense with those of experiments. The antenna has a pencil-beam radiation pattern. The two-wavelength long traveling-wave V-antenna has a gain 10.5 times as large as that of a half-wave dipole. A Scientific Report on this investigation has been issued:

Scientific Report No. 4 "The Traveling-Wave V-Antenna"
by Keigo Iizuka and Ronold W. P. King, March 1965.

Twenty-five copies of this report have been forwarded to the Technical Reports Officer.

A new solution has been obtained by Dr. L. D. Ruquist for the optimum design of broadband reflectionless traveling-wave-dipole receiving antennas when treated in the zero-order-transmission-line approximation. A reflectionless traveling-wave-current distribution is postulated and its differential equation determined. The current distribution is not physically realizable with only a variable resistance coating on the inner conductor of the coaxial line or the antenna because the differential equation contains a frequency independent coefficient. A trial-and-error method was used to select the current distribution that minimizes the reflection coefficient. The reflection coefficient was calculated numerically for each case. Supporting experimental data have been taken.

Dr. Ruquist is also carrying out a study of the junction between perfect and imperfect conductors. The current distribution and related transmission-line parameters have been found for the junction in a coaxial line of a perfectly conducting inner conductor with an inner conductor formed of a resistive coating on a dielectric rod. The problem has been solved by a Wiener-Hopf technique for electromagnetic waves incident from both the perfectly conducting side and from the lossy side. The complex transcendental kernel of the Wiener-Hopf equation has been factored by four methods, one of which is rigorous. The three approximate methods are conventional. The rigorous technique expresses the kernel in the form of a product expansion. A new phase-loci method was used to solve two-dimensional transcendental equations for the poles and zeros of the expansion. The results indicate that conventional transmission-line theory and the approximate techniques of factorization are in error when the resistance per unit length of the resistive coating exceeds the characteristic impedance of the transmission line. Supporting experimental data have been taken.

Mr. L.-C. Shen is doing an experimental and theoretical investigation of the resistive antenna.

A. Theory. The current, the input impedance and the far field pattern of a cylindrical antenna with resistive loading have been determined theoretically. The distribution of the resistive loading along the antenna is a particular function multiplied by a real constant parameter α. The current on the antenna and the field pattern have been evaluated for a wide range of lengths with several different α's ranging from 0 to 1 and for positive integers. They have been found not critically dependent on the parameter α. For α near or greater than 1, the antenna is nonreflecting. A report on this study is being prepared.

B. Experiment. The purpose of the experiment is first to construct an antenna with resistive loading prescribed by the function mentioned in A. and then to compare the measurements of the current distribution and the far field pattern with the theory. The resistive loading is to make use of resistive paint sprayed over a dielectric rod. It has been found that the internal resistance required to realize the antenna can be obtained by either changing the thickness of the coating or the content of the resistive paint. This experiment is in progress.

The research reported in Scientific Report No. 1 under this grant has been published as a paper: "The Cylindrical Antenna with Nonreflecting Resistive Loading," by T. T. Wu and R. W. P. King, IEEE Transactions on Antennas and Propagation, AP-13, No. 3, May 1965.

Two theoretical investigations involving plasma-immersed antennas are being carried out by A. D. Wunsch:

The problem of finding the current distribution on a dipole antenna surrounded by a homogeneous, compressible (finite temperature) plasma is close to solution. A method has been found for obtaining the coefficients of a Fourier series used to describe the current. An examination of the validity of the approximations involved in obtaining these coefficients is now in progress.

A letter commenting on an existing solution of the problem of finding the impedance of such a plasma-immersed antenna has been accepted for publication by the Proceedings of the Institution of Electrical Engineers. In addition, an unpublished note of the author's is described and acknowledged in a book "Antenna Theory" to be published by McGraw-Hill (edited by R. E. Collin and F. J. Zucker). The note is concerned with the surface wave current existing on an infinite antenna immersed in a compressible plasma, and is mentioned in a chapter on antennas in plasma by James R. Wait.

In the other investigation recently begun by Mr. Wunsch the radiation resistance of an electrically short antenna immersed in a cold magneto-plasma is being determined. In this analysis an assumed current distribution is used. Particular attention is being given to the case in which the static magnetic field of the plasma is oriented normal to the axis of the antenna. The method of solution is one recently proposed by F. R. Teshadri.

The staff now working on this Grant consists of one part-time post doctoral fellow, Dr. K. Iizuka, and three graduate students, R. D. Ruquist, L.-C. Shen, and A. D. Wunsch. Available for consultation are Professor R. W. P. King, Associate Professor T. T. Wu, and Assistant Professor B. Rama Rao.

As of May 31, 1965 the unexpended balance remaining to the credit of this Grant was $10,133.26.

Submitted by

Ronold W. P. King
Director Grant NsG-579